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THE INFLUENCE OF DEGENERATION OF ONE VAGUS NERVE UPON THE DEVELOPMENT OF PNEUMONIA

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Since Galen's time experiments have been made upon the vagus nerve and it has been generally known that section of both nerves leads to an early death of the animal. It was however in the seventeenth century that it first became known, through the observations of Valsalva and Morgagni, that the section of the vagi causes lesions in the lungs, lesions which were designated by Vieussens as inflammation. Since this period numerous studies have been made regarding the nature of the influence of cutting of the vagi which leads to inflammation of the lungs, to pneumonia. Many investigators were of the opinion that the section of the nerves leads directly to changes in the pulmonary tissue. The last representative of this group of investigators was Schiff who in the forties of the last century described the lesion as being due to a *neuro-paralytic* action. At the same period, however, Traube carried out many series of well conducted experiments by which he seemed to prove that the section of both vagi causes lesions in the lung by paralysis of the oesophagus, which prevents the transportation of food into the stomach, and by paralysis of the nerves of the larynx, a paralysis which facilitates the entrance of food, saliva, and other foreign bodies into the trachea and the lungs. In other words, the pneumonia following section of both vagi was not due to direct changes in the lung tissue but indirectly to the entrance of foreign bodies through the trachea into the lung; the inflammation following section of both vagi was of the nature of 'aspiration

pneumonia.' In the last six or seven decades many more experiments have been made on the section of both vagi; but all investigators have accepted Traube's interpretation, namely, that the section of the vagi does not cause directly any changes in the tissues. but that the section of the nerves leads to a 'foreign body pneumonia.'

In the above mentioned numerous experiments, as a rule, both vagi were cut; not very many experiments were made by cutting only one vagus. But when such an experiment was made, it was found practically invariably that cutting of one vagus produced neither any clinical effect during life nor were there pathological lesions of the lung at autopsies. I may add that our own experimental experience supports this finding: Cutting of one vagus of a normal dog never leads to a pulmonary disease or lesion.

In the course of the last eight years we carried out in this laboratory numerous experiments on the production of pneumonia by direct injection through the unoperated larynx into the bronchi of normal dogs of various micro-organisms capable of producing various forms of pneumonia. Most of our experiments were recently made with intrabronchial injections of culture of pneumococcus type I, and it was established that the degree of the disease which it produces or the length of time required for the fatal outcome depend upon the virulence of the organism as well as the quantity of the culture injected. Recently a long series of such experiments were carried out with a view of studying the *direct action of vagus nerves upon the development of pneumonia.* Since in these experiments the nerves of the oesophagus and of the larynx remained intact, any acceleration in the development of the disease or the pulmonary lesion could be ascribed only to the interruption of the nervous impulse normally transmitted through the intact vagus nerve to the lung tissue. We shall not enter here into the details of the experiments; but merely state briefly that: In one series of experiments one vagus was cut but no organisms insufflated; these animals, as mentioned above, remained normal. In another series of experiments a definite quantity of the culture was insufflated in normal dogs. These animals either remained alive or died with some pulmonary lesions many days after the injection. In a third series the same culture and the same quantity of it was insufflated on the same day and under the same condition as in the last mentioned series; but in these animals one vagus was cut either four days or ten or more days before the culture was insufflated. These experiments brought to light a striking result. *In the series in which one vagus was cut ten or more days before the insufflation of the culture nearly all*

animals died in less than twenty-four hours after receiving a certain (minimum) amount of the culture, while in the animals in which one vagus was cut four days before the injection or not cut at all, not a single animal died in such a short period, and most of them remained alive. In other words, a certain minimum quantity of culture which was injected ten or more days after one vagus was cut proved to be rapidly fatal; while the injection of the same quantity remained ineffective if no vagus was cut or was cut only a few days before the injection of the culture.

We shall confine ourselves here to the communication of these facts and to only one interpretation of them. First, these experiments show unmistakably that the integrity of a certain form of nerve impulses is indispensable for the normal resistance of the lung tissue to infection or intoxication; if one vagus nerve was cut ten days before the injection of a pneumococcus culture a certain minimum of the culture was nearly invariably rapidly fatal, while in a normal animal or in an animal in which one vagus was cut only a few days before the injection or not cut at all, the same minimum of culture has little or no effect.

Second, for the vessels of most of the tissues it is known that they are innervated by vasoconstrictors and vasodilators. It is further known that the vasoconstrictors degenerate about four days after the section of the nerves, while the vasodilators degenerate only about ten days or later after the section. If we assume that the lungs are also provided with vasoconstrictors and vasodilators and that these vasomotor fibres are carried to the lungs in the vagus nerves, we would have a plausible explanation for the phenomena with which we were confronted in our experiments, namely, cutting of the vagi four days previous to the culture injection is capable of causing degeneration of only the vasoconstrictor nerve fibres, which may not be indispensable to the upholding of the normal activity of the lung tissue. If, however, the injection is made about ten days or longer after the cutting of one vagus, also the vasodilators are degenerated and their integrity may be indispensable for upholding the circulation and the normal resistance of the lung tissue to infection or intoxication by a virulent culture of pneumococcus type I.

At any rate, our experiments brought out the facts that nerve impulses are running through the vagus nerves which are important to the upholding of the normal resistance of the lung tissue itself. That even one vagus nerve is an important factor in this process; and that these activities of the vagus nerves can be recognized only after an intrabronchial or intratracheal injection of a virulent culture ten days after the cutting of one vagus.

Furthermore, the fact that the intrabronchial injection of a minimum culture proved fatal only when the injection was made ten days after the section of one vagus and the further consideration of the fact that it takes about ten days for the degeneration of vasodilators lend support to the assumption that it is the degeneration of the vasodilators which is responsible for the fatal results observed in our experiments.

ON THE ETHOLOGY OF CHITON TUBERCULATUS[1]

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Chitons of the species *C. tuberculatus* Linn. are an important element in the shore-fauna of the Bermuda Islands. Their large size, their abundance, and the diversity of the habitats which they occupy within the tidal zone, make them animals appropriate for a variety of investigational purposes—notably for study of the relations found among the features of local habitats, on the one hand, and, on the other, certain definite sensory and other modifications of these animals which develop with the advancing age of a chiton. The organization of the Placophora, probably primitive with reference to that of other molluscs, makes it important also to obtain physiological evidence as to the characteristics of the nervous system in these animals. On the structural side it is well known that the chiton central nervous system is in the form of strands, containing perikarya throughout their length, but with no concentrations of these cells into distinct ganglionic enlargements.

We find in *Chiton tuberculatus* decided indications of but a relatively incipient degree of nervous centralization. The autonomy of the several portions of the body, or of the parts into which it may be artificially separated, is conspicuous. At the sides of the body, the parts (girdle, ctenidia, etc.) innervated by the pallial strands are pronouncedly homolateral in their responses. The coördinating mechanism for the production of pedal locomotor waves is locally contained. The absence of strong anterior nervous centralization is nicely indicated by the exhibition of backward creeping (especially in Ischnochiton) under proper conditions of stimulation by light.

Of the several kinds of sensory receptors which we have distinguished in *Chiton tuberculatus*, the nervous elements in the shell tegmenta, now for the first time proved to be photosensitive, are perhaps the most